**NASA/TM-2002-210005**

# SIMBIOS Project 2001 Annual Report

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March 2002

*Chapter 9*

# Refinement of Protocols for Measuring the Apparent Optical Properties of Seawater

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## 9.1 INTRODUCTION

Ocean color satellite missions, like the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) or the Moderate Resolution Imaging Spectroradiometer (MODIS) projects, are tasked with acquiring a global ocean color data set, validating and monitoring the accuracy and quality of the data, processing the radiometric data into geophysical units using a set of atmospheric and bio-optical algorithms, and distributing the final products to the scientific community. The long-standing objective of the SeaWiFS Project, for example, is to produce water-leaving radiances to within 5% absolute (Hooker and Esaias 1993). The accurate determination of upper ocean apparent optical properties (AOPs) is essential for the vicarious calibration of ocean color data and the validation of the derived data products, because the sea-truth measurements are the reference data to which the satellite are compared (Hooker and McClain 2000). The uncertainties associated with *in situ* AOP measurements have various sources, such as, the deployment and measurement protocols used in the field, the absolute calibration of the radiometers, the environmental conditions encountered during data collection, the conversion of the light signals to geophysical units in a data processing scheme, and the stability of the radiometers in the harsh environment they are subjected to during transport and use.

In recent years, progress has been made in estimating the magnitude of some of these uncertainties and in defining procedures for minimizing them. For the SeaWiFS Project, the first step was to convene a workshop to draft the SeaWiFS Ocean Optics Protocols. The protocols adhere to the Joint Global Ocean Flux Study (JGOFS) sampling procedures (Joint Global Ocean Flux Study 1991) and define the standards for optical measurements to be used in SeaWiFS radiometric validation and algorithm development (Mueller and Austin 1992). The protocols are periodically updated as deficiencies are identified and outstanding issues are resolved (Mueller and Austin 1995, and Mueller 2000). The follow-on inquiries into controlling uncertainties investigated a variety of topics. The SeaWiFS Intercalibration Round-Robin Experiment (SIRREX) activity demonstrated that the uncertainties in the traceability between the spectral irradiance of calibration lamps were approximately 1.0%, and the intercomparisons of sphere radiance was approximately 1.5% in absolute spectral radiance and 0.3% in stability (Mueller et al. 1996). The first SeaWiFS Data Analysis Round Robin (DARR-94) showed differences in commonly used data processing methods were about 3–4% of the aggregate mean estimate (Siegel et al. 1995). Hooker and Aiken (1998) made estimates of radiometer stability using the SeaWiFS Quality Monitor (SQM), a portable and stablelight source, and showed the stability of radiometers in the field during a 36-day deployment was on average to within 1.0% (although some channels occasionally performed much worse). More recently, Hooker and Maritorena (2000) quantified differences in the in-water methods and techniques employed for making radiometric measurements and demonstrated a total uncertainty in the measurement of in-water AOPs at approximately the 3% level.

## 9.2 RESULTS

*Open Ocean*

The SeaWiFS Field Team has combined the collection of ground-truth observations with specific experiments to investigate the sources of uncertainties in AOP measurements.